DISCOVERY

58(314), February, 2022

Identification and Utilization of Potential Indigenous Fodder Trees and Shrubs as Dry Period Ruminant Feed in Bako-Tibe district, West Shewa Zone, Ethiopia

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To Cite:
Keba D, Tolemariam T, Demeke S, Hundie D. Identification and Utilization of Potential Indigenous Fodder Trees and Shrubs as Dry Period Ruminant Feed in Bako-Tibe district, West Shewa Zone, Ethiopia. *Discovery*, 2022, 58(314), 97-110

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Peer-Review History
Received: 30 November 2021
Reviewed & Revised: 03/December/2021 to 09/January/2022
Accepted: 10 January 2022
Published: February 2022

Peer-Review Model
External peer-review was done through double-blind method.

ABSTRACT

Indigenous fodder trees and shrubs are important feed resources in Ethiopia during the dry season. This study was conducted to assess and provide comprehensive information on the availability, utilization, farmers' perception and chemical composition of these trees. Ten potential Indigenous fodder trees and shrubs (5 trees and 5 shrubs) in the lowland and eight (5 trees and 3 shrubs) in mid-altitude were identified and selected. The scores credited and preferences by farmers to the selected traits varied significantly (P<0.001) among different species. The mean CP content of IFTS was 17.9% within a range between 8.6-26.9% for Carissa edulis and Acanthus polystachyus respectively, indicating that these browse species were of high potential in feeding value as measured by CP content. There was significant variation (P<0.001) between the browse species in mean CP, NDF, ADF, ADL, EE and TT (Total tannin) contents. Moreover, there was significant (P<0.01) difference between the browse species attributed to altitudes in average NDF, ADF, and ADL contents. Shrubs contained significantly higher (P<0.01) CP and EE content than browse trees; whereas trees contained significantly (P<0.05) higher mean NDF. The correlation between farmers perception of feed value scores of Indigenous fodder trees and shrubs and the laboratory result of CP content was positive and significantly (P<0.05) strong (r =0.60). However, there was no positive and strongly significant (P>0.05) correlation between farmers perception of feed value scores of IFTS and the analytic result of ADF, ADL and TT content in both studied agro-ecologies. The results obtained indicated that about 96.8 and 94. 3% of the lowland and mid-land respondents respectively, feed the leaves and twigs/pods of the IFTS species fresh. In conclusion, most of the fodder species identified in the study area are potential feed resources for ruminant animal feeding during the dry period in Ethiopia. Further animal evaluation for the promising and widely available indigenous fodder trees and shrubs aimed at including into dry period ruminant animal feeding system seems to be the future direction of research.

DISCOVERY SCIENTIFIC SOCIETY

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

Keywords: fodder trees; shrubs; browse; feed value; ruminant

1. INTRODUCTION

The contribution of livestock to global income from agriculture is estimated to be about 40% (Nabarro and Wannous, 2014). In Ethiopia, agriculture contributes about 43.2% of the country's Gross Domestic Product (GDP) and provides about 85% of employment opportunities (CSA, 2016). The livestock sub-sector was accountable for 13-16% of the total agricultural GDP (Yayneshet, 2010). Moreover, livestock have an important contribution to crop production through provision of traction power and manure in the crop-livestock mixed production system (Romney *et al*., 2003; Tilahun and Kirkby, 2004). Livestock are the leading contributors to the livelihood of the rural community in Bako-Tibe district of West Shewa Zone. Nevertheless, the productivity of the Ethiopian livestock is low mainly due to poor nutrition (among others) (Yeshitila *et al*., 2008; Daniel, 2018).

Feed resources in Ethiopia mainly comprises of natural and improved pastures, crop residues, forage crops, agro-industrial by-products and non-conventional feeds (Tolera, 2012; CSA, 2015; Daniel, 2018). Natural pastures are seasonally available and diminishing from time to time, resulting in serious feed shortage affecting production and productivity during dry period (Solomon, 2004; Mesay *et al*., 2013). On the other hand, the available crop residues are low in metabolized energy and crude protein (Devandra, 1991; Preston, 1995; Tingshuang *et al.*, 2002). Thus, it is important to look for strategies of tackling feed shortages and nutrient deficiencies particularly during the dry period.

Fodder trees and shrubs are widely available and play significant role in arid areas where moisture is limiting (Eshete, 2002).The importance of browses is universal throughout the tropics, where they serves as leading feed resources, especially in the drier regions and during dry season when natural pastures and green vegetation's dry up and deteriorate both in quality and productivity (Devendra, 1990). However, no exhaustive study has been conducted in Bako-Tibe district of West Shewa Zone on the available fodder trees and shrubs from the point of view of their utilization. Therefore, this study was conducted with aim to assess and provide inclusive information on the potential indigenous fodder trees and shrubs, their utilization and associations with farmers' preferences, and characterize their nutritive value.

2. MATERIALS AND METHODS

Description of the Study Area

This study was conducted in Bako-Tibe district of West Shewa Zone in the Oromia Regional State. The study district is located at 250Km West of Addis Ababa at an altitude of 1650m above sea level. The district receives mean annual rainfall of 1200 mm in a bimodal distribution, 80% of which falls between May and September. The area has a mean relative humidity of 59% and minimum and maximum temperature of 13.5 and 27°C, respectively. The study district had 32 *Kebeles* (Peasant Association) of which 28 were rural. Topographically; plain lands (plateau) constituted about 60%, rugged terrain was 22%, mountains were 5% and, valleys (gorges) covered 4.5% of the total area. Agro ecologically, lowland, midland and highland are accountable for about 50, 37.5and 12.5% of the total area of the district (BTDCSO, 2017). The low and mid-land make up the majority (about 90 %) of the total area of the study area.

Selection of Participating Households

A total of three *kebeles* (two from the lowland and one from the midland) were selected using a stratified random sampling. Ninety-nine households (sixty-four from the lowland and thirty-five from the mid-land) were randomly selected to participate in the survey. Well prepared and pre-tested semi-structured questionnaires were used to collect primary data on the characteristics of the respondents and animal feed resources available in the study area. Group discussions and key informants' interview was also conducted to generate all the necessary data on human and animal population, availability and type of fodder plants [Indigenous Fodder Trees and Shrubs (IFTS)] commonly used for livestock feeding, including their utilization and ranking based on farmers' preference trait scores. The sample size of the participating households was determined using a formula suggested by Yamane (1967).

$$n=\frac{N}{1+N(e^2)}$$

Where, n is sample size computed; N is the total households in the study area and e is the error term set at 0.1.

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Identification of Potential IFTS

A cross-sectional field survey aimed at observing the predominant IFTS was conducted between January and March. Criteria were set for selection of IFTS based on focused group discussion with knowledgeable farmers and key informant farmers were requested to list the most important and commonly used IFTS, including their characteristics and benefits based on farmers' perception. Feed value, biomass yield, ever greenness, multiple use, and compatibility scores were considered during the discussion. Feed value preference scoring was done on a point scale from 1 (poor) to 4 (highly preferred) (Roothaert and Franzel, 2001; Abebe *et al*., 2008). The ranking exercise was undertaken on an individual basis by selected farmers from both altitudes. Sample collections were done for the most frequently selected trees and shrubs. Samples from different trees of the same species and location were treated as replicates and three replicates per location were collected for each species. Samples of leave and twigs were taken at three heights from bottom, middle and top of the plants, and pooled, air dried, ground with the use of Whilley mill and stored in air tight plastic container until needed for chemical analysis.

Statistical Analysis

Qualitative data were analyzed using descriptive statistics. Testing for the relationships between farmers' assessment of IFTS feed value scores and the relative assessments obtained from laboratory-based chemical analysis, Spearman's rank correlation analysis was performed independently for each agro-ecology using the General Linear Model (GLM) in SPSS version 20. A two-way analysis of variance was carried out to see mean differences between altitudes, fodder trees and shrubs and their interaction for biomass yield, farmers feed preference score values and chemical analyses.

The statistical model used for analysis of variance was the following:

$$Yijk = \mu + \alpha i + \beta j + (\alpha\beta)\ ijk + \varepsilon ijk$$

Where,

Yijk= Response variables (estimated yield, chemical composition, farmers' selection scores for IFTS)

μ = overall mean

αi = altitude effect

Bj = effect of ith types of plant nature (trees vs shrubs)

$(\alpha\beta)ij$ = the interaction effect between the altitude and plant type

εijk = random error

3. RESULT AND DISCUSSION

Common Indigenous Fodder Trees and Shrubs (IFTS)

The list of fodder trees and shrubs selected by many of the respondents is presented in Table 1. About 80% of the listed IFTS were common in both agro-ecologies; whereas the remaining 20% (*Ficus palmata* and *Gardenia ternifolia*) were common only in the lowland altitude and not stated as common animal feed in the mid-land agro-ecology. The former shrub was particularly of a riverine type that grows following the Gibe River basin remained to be a dominant browse for cattle during the severe dry season of the year.

Five browse tree and three shrub species were common in both altitudes, but differ in the extent of availability. For example, *Cordia africana* was more common in the lowland agro-ecology, while *Carissa edulis* and *Acanthus polystachyus* were relatively widely available in the mid-land altitudes of the study area. The number of respondents indicating the browse species as animal feed varied widely. *Cordia africana* was selected by all (100%) respondents of the lowland altitude while; *Stereospermun kunthianum* was selected only by 31.3% of the respondents of the same agro-ecology. *Vernonia amygdalina* was selected by 100% of the respondents of the mid-altitude, while *Ficus vasta* was picked up only by 34.3% of the respondents of mid- altitude. In the present study, *Albizzia schimperiana* was less frequently listed as animal feed in both agro-ecologies and 15.6% of the lowland and 20% of the mid-land respondents. The result elucidated that this browse species was comparatively less palatable and less visited. The difference in the frequency of selecting the browse species as livestock feed might be associated with the difference in availability, palatability and accessibility.

As indicated in Table 1, the results obtained tends to indicate that the use of diverse browse species as livestock feed seems to be low in the study area, mainly due to the continuous and indiscriminate clearing of the browse species for the expansion of

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

cultivated farmland, which might have ultimately resulted in the disappearance of most palatable species. For example, *Carissa edulis* and *Acanthus polystachyus* were among the known browse shrubs known for their palatability and popularity in utilization as feeds; unfortunately subjected to vanishing due to expansion of arable lands. Similar observations were reported from Horro and Guduru districts (Kassahun, 2016) and the results of the current study is inconsistent with that of Yisehak and Geert (2013) who reported an extensive use of fodder trees and shrubs in the lowland areas of the country. In addition to the use for livestock feeding, the listed fodder trees and shrubs have multiple uses like fire wood, construction (housing, fence etc.), furniture, shade and packaging (cord) as in the case of *Ficus palmate* (Table 1). Furthermore, *Vernonia amygdalina* has additional advantage of having medicinal value and reported to have been used in the treatment of gastric burn. The results of this study is in agreement with that of Yisehak and Geert, (2013); Kassahun, (2016), who reported a diverse traditional uses of indigenous trees and shrubs in different of parts of the country.

Table 1. List of important trees and shrub species known as livestock feeds in the study area

Vernacular Name	Scientific name	Family name	selected by	% of respondents		Parts used	Uses
				LL	ML		
Waddeessa	*Cordia Africana*	*Bignoniaceae*	L &M	100	25	L+F	1,2,3,5,6,7
Eebicha	*Vernonia amygdalina*	*Asteraceae*	L&M	96.8	100	L+P	1,2,3,4,6,
Luugoo	*Ficus palmate*	*Moraceae*	LL	78.1	-	L+P	1,2,3,,6,8
Laaftoo	*Acacia abyssinica*	*Fabaceae*	L&M	37.5	65.6	L+P	1,2,3,5,6
Botoroo	*Stereospermum kunthianum*	*Bignoniaceae*	L&M	31.3	21.9	L	1,2,3,6
Qilxuu	*Ficus vasta*	*Moraceae*	L&M	70.3	34.4	L+F	1,2,3,6
Agamsa	*Carissa edulis*	*Apocynaceae*	L&M	32.8	46.9	L+F	1,2,3,
Kosorruu	*Acanthus polystachyus*	*Achantaceae*	L&M	37.5	43.8	L+P	1,2,3
Gambeela	*Gardenia ternifolia*	*Rubiaceae*	LL	21.9	-	L+P	1,2,3,6
Mukarbaa	*Albizzias chimperiana*	*Leguminosae*	L&M	28.1	31.3	L+P	1,2,3,5,6

L&M = used in the low and mid altitude area, LL = mostly in lowland, L=leaf, P=pod, F=fruit, 1=feed, 2=construction, 3=firewood, 4= medicine, 5=charcoal, 6= shade.7=furniture, 8=packing (cord)

Farmers' Preferable Trait Scores for IFTS

The result of score rates given to each species of IFTS according to the traits is presented in Table 2. The traits (parameters) targeted to rate IFTS by farmers in the ranking exercise for each of the desired attributes were feed value, biomass, ever greenness and potential to re-grow after defoliation, multiple uses and compatibility with other crops. Significant difference (P<0.001) was observed for all the scores of selected traits of the browse species in both low and mid-lands of the study area. The results obtained revealed that the mean subjective score attributes assigned to feed values of the selected browse species was 3.2and 3.1 for the lowland and mid-land agro-ecology, respectively. The mean values obtained ranged between 2.1 and 3.7 in the lowlands and 2.2 and 3.6 in mid altitude. Significantly (P<0.001) lower value of 2.1 and 2.2 score was recorded for *Albizzia schimperiana* in the low and midland, respectively. On the other side, significantly (P<0.001) higher score 3.7 and 3.6 value were recorded for *Vernonia amygdalina* in the low and mid-land, respectively. The scores of this trait were similar (P>0.05) between the two altitudes of the study area. This may reflect that farmers' indigenous knowledge and experience in categorizing the IFTS in terms of feeding (nutritional) value was similar across altitudes; may be due to wider chance of sharing experiences on the utilization of these feed resources. In fact, the availability of most of the selected browses in both altitudes might probably be another contributing factor for the similarity of the observed scores of this trait. Similar trends of farmers' native knowledge in categorizing feed value of browses to the present study were previously reported for the northern and southern parts of Ethiopia (Abebe *et al*., 2008; Yisehak and Geert, 2013).

The average score biomass (amount of edible parts: leaf, twigs, pods and fruits) of the selected browse species of the lowland was 2.6 ranging from 2.3 for *Stereospermum kunthianum* and *Gardenia ternifolia* to 3.4 recorded for *Cordia africana.* Similarly, the average subjective biomass score attributes in the mid-land was 2.6 within a range of 2.2-3.2 for *Stereospermum kunthianum* and *Cordia africana, respectively*. Respondents associated the biomass yield of browse species with size and abundance of browse trees and shrubs. For example *Cordia africana* is among trees that grows larger and faster producing large biomass despite its leaf shedding property for few weeks. From the point of view of the respondents, the issue of accessibility of the whole or edible plant part is the factor determining the biomass obtained from the plants. The overall biomass score attribute recorded for browse trees was higher (P<0.01) than those recorded for browse shrubs (Table 3).

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

The results of growth, re-growth and ever-greenness traits of selected species are presented in Table 2. The result of the current study showed that there was significant (*P*<0.01) difference among the selected browse species in these parameters. The mean greenness and regrowth potential value of 3.1 was documented for the selected browse species in the lowland within a range of 2.3-3.7 recorded for *Vernonia amygdalina* and *Ficus palmata,* respectively. Similarly, the mean greenness and regrowth potential of 3.0 was obtained from the selected browse species in mid-altitude ranging between 2.4-3.5 score for *Vernonia amygdalina* and *Albizzia schimperiana,* respectively. There was no significant (*P*<0.05) difference between the agro-ecologies in the overall average growth, re-growth and ever-greenness. In both agro-ecologies of the current study areas, the growth and re-growth/greenness potential values was significantly (*P*<0.05) higher for browse trees than browse shrubs (Table 3).The results suggested that except for a riverine shrub *Ficus palmata*, most of other browse shrubs suffer from dry weather and become less capable of regenerating thereby appearing less green than most of the browse trees which could relatively withstand high temperature and evapo-transpiration, and remain relatively green. This might be attributed to the long root of browse trees capable of going deep into the ground, withdraw and store water better than shrubs. In addition, broad leaved trees like *Ficus vasta* have waxy leaves that conserve water and maintain greenness during the dry season.

Table 2. Scores of different traits of IFTS by farmers of low and mid-land (score1=low; score 4=high)

Species	Feed value	Biomass	Ev/ greenness & re-growth	Multiple use	Compatibility
Lowland					
Cordia Africana	3.5^{b}	3.4^{a}	2.8^{c}	3.8^{a}	1.6^{b}
Vernonia amygdalina	3.7^{a}	2.8^{c}	2.3^{d}	2.8^{e}	1.5^{b}
Ficus palmate	3.4^{b}	2.7^{c}	3.7^{a}	3.1^{d}	1.3^{c}
Acacia abyssinica	3.4^{b}	2.5^{d}	3.5^{a}	3.3^{c}	2.2^{a}
Stereospermum kunthianum	2.9^{c}	2.3^{e}	2.9^{c}	2.4^{f}	1.4^{bc}
Ficusvasta	3.0^{c}	2.6^{c}	3.1^{b}	3.1^{d}	1.4^{bc}
Carissa edulis	3.4^{b}	2.4^{d}	3.5^{a}	2.3^{fg}	1.5^{b}
Acanthus polystachyus	3.5^{b}	2.4^{d}	2.9^{c}	2.2^{g}	1.3^{c}
Gardenia ternifolia	2.9^{c}	2.3^{e}	3.0^{c}	2.4^{f}	1.5^{b}
Albizziaschimperiana	2.1^{d}	3.0^{b}	3.6^{a}	3.5^{b}	2.1^{a}
Mean	3.2±0.19	2.6±0.11	3.1±0.14	2.9±0.17	1.6±0.10
	***	***	***	***	**
Mid-land					
Cordia Africana	3.2^{c}	3.2^{a}	2.7^{c}	3.7^{a}	1.5^{cd}
Vernonia amygdalina	3.6^{a}	2.9^{b}	2.4^{d}	2.9^{c}	1.6^{c}
Acacia abyssinica	3.3^{bc}	2.6^{c}	3.4^{a}	3.2^{b}	2.3^{a}
Stereospermum kunthianum	2.9^{d}	2.2^{d}	2.9^{b}	2.4^{d}	1.5^{cd}
Ficusvasta	2.8^{d}	2.5^{c}	3.0^{b}	3.0^{c}	1.3^{d}
Carissa edulis	3.4^{b}	2.3^{d}	3.5^{a}	2.2^{e}	1.4^{d}
Acanthus polystachyus	3.4^{b}	2.3^{d}	2.8^{bc}	2.1^{e}	1.4^{d}
Albizziaschimperiana	2.2^{d}	2.9^{b}	3.5^{a}	3.6^{a}	2.1^{b}
Mean	3.1±0.09	2.6±0.07	3.0±0.08	2.9±0.12	1.7±0.06
Significance	***	***	***	***	**
LL VS ML	NS	NS	NS	NS	NS

LL =Lowland, ML=mid -land, * =P<0.05, **=P<0.01, ***=P<0.001 Means within the same column with different superscripts are significantly different (P<0.05).

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

Table 3. Summary of the effect of altitude on subjective scores of selection characteristics for IFTS for the low and mid-land areas (score 1=low; score 4=high)

Selection traits	Lowland		Mid-land		Mean	P		
	Trees	Shrubs	Trees	Shrubs		Agro	TvsS	Agro*Type
Feed value	3.0±0.15	3.4±0.16	2.9±0.16	3.5±0.19	3.1	NS	**	NS
Biomass	2.8±0.15	2.5±0.16	2.7±0.17	2.5±0.19	2.6	NS	**	NS
Regrow/greenness	3.2±0.16	3.0±0.17	3.1±0.16	2.9±0.2	3.1	NS	*	NS
Multiple use	3.2±0.18	2.6±0.18	3.2±0.2	2.4±0.2	2.9	NS	**	NS
Compatibility	1.7±0.1	1.4±0.12	1.7±0.1	1.5±0.12	1.6	NS	*	NS

** = P <0.01, * = P< 0.05, NS = non-significant, T= tree, S= shrub

The results of the multiple use score is also presented in Table 2. There was significant (*P*<0.01) difference between the selected browse species in multiple use values in both agro-ecologies. Mean multiple use value 2.9 score was recorded from lowland agro-ecology within a range of 2.2-3.8 documented for *Acanthus polystachyus* and *Cordia africana,* respectively. Similarly, the mean multiple use score 2.9 was documented for midland agro-ecology within a range between 2.1-3.7 recorded for *Acanthus polystachyus* and *Cordia africana,* respectively. There was no overall mean significant (*P*>0.01) difference in multiple use and score value recorded among the two agro-ecologies. On the contrary, a multiple use scores values recorded for the tree species was significantly (*P*<0.01) outweighed that of shrub species. This might be because of the many uses of tree species for purposes like construction, livestock housing and crops shade; timber for various expensive household furniture and other purposes.

The highest compatibility score value of 2.2 and 2.3 was recorded for *Acacia abyssinica* in the lowland and mid-land, respectively. On the contrary, the lowest score value of 1.3 was recorded for both *Acanthus polystachyus* and *Ficus palmate* in the lowland. The same score (1.3) was recorded for *Ficus vasta* in the mid-land agro-ecology. The results of the current study indicated that the compatibility scorevalues obtained are below the average for most of the species in both altitudes. However, there was significant (*P*<0.01) difference between the tree and shrub species in both agro-ecologies. Similar results were reported earlier for these parameters of fodder trees and shrubs (Abebe*et al*., 2008; Yisehak and Geert, 2013; Kassahun, 2016). In conclusion, farmers' indigenous knowledge in valuing the traits was fairly exploited and the importance of the browse species as a feed resource (feed value trait) in both altitudes is mostly limited to the dry season of the year.This account is similar with reported results of the study conducted in Horro-Guduru areas of Ethiopia (Kassahun, 2016).

Potential Nutritive Value of the Selected IFTS

The results of the laboratory chemical analysis ofthe selected IFTS are presented in Tables4, 5 and 6. The overall average DM content of the selected browse species was 95.2%. This value is close to the values reported by Beyene *et al*. (2010) and Megersa *et al*. (2017) who reported 95.4 in Asossa Zone and 93.52% in Gambella Peoples Regional State, respectively. It is however, slightly higher than the 91.4% reported by Kassahun (2016) in Horro-Guduru Wellega, and the 90.3% value reported by Shenkute *et al*. (2012). The variations in dry matter observed might be linked to the differences in times of sampling, species of plants, and stage of harvest (Gworgwor *et al*., 2006).

The mean total ash content of browse species of the lowland was 9.4% with a range of 5.1-15% recorded for *Albizzia schimperiana* and *Ficus palmate,* respectively (Table 4). Likewise, the mean total ash content of browse species of the mid altitude was 9.9% with range of 7.5-13.6% recorded for *Albizzia schimperiana* and *Vernonia amygdalina,* respectively. There was significant (*P*<0.001) difference in total ash content among the selected browse species in both study altitudes. There was no significant (*P*>0.05) difference between the two agro-ecologies in mean total ash content; whereas there were wide variation (*P*<0.01) between trees and shrubs in mean total ash content, the values of which was higher for shrubs (Table 6). The difference in mean total ash observed among species may be associated with the difference in efficiency of individual species to absorb and retain minerals from the soil. It might also be due to type of the soil they were growing on. The mean total ash content of the selected browse species (9.7%) obtained from the current study is within the range of 8.39–14.11% of ash content of browse species reported from for Wolayita Zone (Takele *et al*., 2014) and close to mean total ash content of 10.8% reported for IFTS harvested from Borena rangeland (Aster *et al*., 2012). A mean total ash content of 9.62% was reported for the browses sampled from Gambella by Megersa *et al*. (2017). The mean total ash content obtained in the current study was less than 13.6 % reported by Kassahun (2016). The results of the current

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study was in line with that of Muluken *et al*. (2015) who reported mean total ash content of 7-13% for IFTS in the Northeastern dry regions of Ethiopia.

Crude protein content plays a leading role in determining the feeding value of fodder, though ADF, polyphenols like lignin and tannin contents mayimpair its availability to the animal through lignification's (Raj, 2006). The CP content varied significantly (P<0.001) between 8.6% (*Carissa edulis)* and 26.6% (*Acanthus polystachyus)* in the lowland with mean value of 17.5% (Table 4). Similarly, the CP content of the selected browse in the mid altitude, varied significantly (P<0.001) between 9.4% *(Carissa edulis)* and 26.9% *(Acanthus polystachyus)* with average value of 18.3%. The effect of altitude on the CP content of the browse species is shown in Table 6.The result shows that there was no significant (P>0.05) difference in mean CP contents of the selected species attributed to agro-ecology. On the contrary the CP content of the browse shrubs were significantly (P<0.05) higher than that of browse trees. The higher CP content of the shrubs might be attributed to their location close to rivers, bearing adequate leaves and appearing green even during the dry season of the year, which in turn is associated with better CP content. On the other hand, the selected trees were broad leaved and located at a distance from the rivers (moisture) and subjected to partial drying and leaf shedding which in turn might resulted in lower CP content.

Table 4 Chemical composition of the leaves of selected browse species from the lowland

List of IFTS	Composition (% DM)							
	DM	Ash	CP	NDF	ADF	ADL	EE	TT
Cordia Africana	97.3	8.9^{e}	17.5^{e}	80.3^{a}	43.8^{d}	19.9^{f}	2.4^{e}	4.0^{d}
Vernonia amygdalina	97.3	12.4^{b}	25.3^{b}	49.3^{h}	26.4^{j}	22.1^{e}	2.8^{d}	8.8^{a}
Ficus palmate	96.8	15.0^{a}	18.6^{d}	56.6^{e}	44.9^{c}	31.5^{b}	2.1^{e}	3.9^{d}
Acacia abyssinica	97.4	9.4^{d}	21.9^{c}	68.4^{b}	51.4^{b}	12.5$_{h}$	3.8^{b}	7.1^{b}
Stereospermum kunthianum	97.0	8.2^{e}	13.9^{f}	55.0^{f}	40.8^{e}	26.1^{d}	2.9^{d}	6.6^{c}
Ficus vasta	96.7	8.7^{e}	11.8^{h}	57.9d	35.5^{g}	20.3^{f}	2.4e	3.8^{d}
Carissa edulis	96.8	6.2^{f}	8.6^{i}	52.1g	26.0^{j}	9.4^{i}	8.9^{a}	7.3^{b}
Acanthus polystachyus	93.9	11.4^{c}	26.6^{a}	62.0c	39.4^{f}	29.1^{c}	3.4^{c}	6.4^{c}
Gardenia ternifolia	95.1	8.9^{e}	13.3^{g}	63.0c	54.9^{a}	32.2^{a}	2.1^{e}	8.6^{a}
Albizzia schimperiana	97.8	5.1^{g}	17.4^{e}	41.0^{f}	29.7^{i}	16.5^{g}	1.4f	7.8^{b}
Mean	96.6	9.4	17.49	58.6	43.1	21.8	3.2	6.4
SE	0.31	0.03	0.99	0.07	0.025	0.033	0.019	0.13
Sig.	*	***	***	***	***	***	***	***

Means within the same column with different superscripts are significantly different (P<0.05) DM= dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent lignin; TT = Total tannin; * = P<0.05; ** P<0.01; ***=P<0.001; NS = non-significant

Table 5 Chemical composition of the leaves of selected browse species from the mid-altitude

List of IFTS								
	DM	Ash	CP	NDF	ADF	ADL	EE	TT
Cordia Africana	95.2^{a}	9.8^{d}	17.9^{d}	72.4^{a}	38.2^{a}	17.2^{c}	2.6^{e}	3.6^{d}
Vernonia amygdalina	94.9^{a}	13.6^{a}	25.8^{b}	41.5^{g}	22.6^{g}	15.0^{e}	3.0d	8.3^{a}
Acacia abyssinica	94.5^{b}	10.2^{c}	22.3^{c}	62.9^{b}	31.4^{b}	10.1^{g}	3.3c	6.9^{b}
Stereospermum kunthianum	94.8^{b}	9.7^{d}	14.2^{e}	51.7^{d}	27.3^{d}	18.5^{a}	3.1^{d}	6.2^{c}
Ficusvasta	93.8^{c}	9.3^{e}	12.1^{f}	49.9^{e}	25.4^{e}	13.1^{f}	2.5^{e}	3.7^{d}
Carissa edulis	94.2^{c}	8.0^{f}	9.4^{g}	47.6^{f}	24.7^{f}	9.1^{h}	7.6^{a}	6.5^{c}
Acanthus polystachyus	92.4^{d}	10.8^{b}	26.9^{a}	56.0^{c}	28.1^{c}	18.1^{a}	3.7^{b}	6.1^{c}
Albizziaschimperiana	95.3^{a}	7.5^{g}	18.0^{d}	39.7^{h}	28.3^{c}	15.8^{d}	1.9^{f}	7.3^{b}
Mean	94.4	9.9	18.3	52.7	28.2	14.6	3.4	6.1^{c}
SE	0.031	0.019	1.2	0.012	0.022	0.013	0.016	0.15
Sig.	***	***	***	***	***	***	***	***

Means within the same column with different superscripts are significantly different (P<0.05) DM= dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent lignin; TT = Total tannin; * = P<0.05; ** P<0.01; NS = non-significant

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Table 6. Nutritive value analysis of selected IFTS in the low and mid-land

Composition	Lowland		Mid altitude		Mean	Agro	Type	Agro*Type
	Trees	Shrubs	Trees	Shrubs				
DM%	97.2±0.039	95.9±0.047	94.7±0.21	93.8±0.27	95.2	**	**	NS
Ash%	8.1±0.052	10.8±0.039	9.3±0.43	10.8±0.56	9.7	NS	**	NS
CP%	16.5±0.72	18.44±0.84	16.9±0.76	20.7±0.91	17.9	NS	*	NS
NDF%	60.1±0.11	56.6±0.069	55.3±2.56	48.3±3.35	56.0	**	*	NS
ADF%	40.2±0.033	41.1±0.039	30.1±1.03	25.1±1.32	35.4	***	NS	NS
ADL%	19.1±0.039	26.5±0.053	14.9±0.88	14.0±1.15	19.7	***	**	NS
EE	2.6±0.031	3.9±0.023	2.7±0.35	4.8±0.45	3.3	NS	***	NS
TT%	5.9±0.82	7.0±0.79	5.5±0.71	6.9±0.92	6.3	NS	NS	NS

DM= dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL =acid detergent lignin; EE, = ether extract (crude fat); TT = total tannin; * = $P<0.05$, ** $P<0.01$; ***=$P<0.001$

Le Houérou (1980) indicated that tree species have the ability to remain green for a longer period due to their deep root systems that enable them to draw water and nutrients from deep in the soil profile, which contributes positively to the CP content of the foliage. The results of the current study was contrary to that of Kassahun (2016) who reported browse trees contain better CP than browse shrubs. The overall mean CP content of 17.9%, reported from the current study is consistent with many studies and falls in the ranges of 10.98-21.08% reported for selected IFTS of Bale rangeland (Aster *et al*., 2012); 10.8-21.08% and Gibe valley (Yisehak and Geert, 2013). The current results were also in agreement with that of Kassahun, (2016), who reported CP content of 8.1-22.2% of IFTS collected from Horro-Guduru District of Wellega. Crude protein content of 18.6-24.4% was reported by Aynalem and Taye (2008) from south western Ethiopia. Shenkute *et al*. (2012) also reported close values from the mid- rift valley of Ethiopia. The crude protein content recorded from the current study was slightly higher than that of Megersa *et al*. (2017) who reported that no single browse species contained ≥20% CP among the browse species sampled from Gambella. However, the CP obtained from the present study well complies with the earlier conclusions that indicated most of the browse trees and shrubs contain more than 10% crude protein (Dicko and Sikena, 1992).

According to Sampaio *et al*. (2010), increasing the dietary CP concentration close to 8 - 10% of DM was found to optimize the use of low-quality tropical forages by rumen microbes, leading to sufficient forage intake. Ranjhnan (2001), also showed that intake of forages is limited when CP content is less than 10%, and at CP content of ≤ 6.5% results in drop of forage intake; whereas at CP content of 13%, the rumen microbes were found to establish well. Luckily enough, the overall average CP content of all IFTS considered in the current study was higher than the minimum CP required for optimum rumen bacteria. This seems to qualify the possibility of using locally available IFTS as an alternative plant protein sources to improve the nutritive values of poor quality feed resource during the dry season. According to Raj and Kumar (2006), and Kazemi *et al*. (2012), feeds containing ≥ 20% CP are valued as feed of high quality standard and those with CP content of ≤8% are considered to be of poorer quality. The mean CP content of selected browse species like *Acanthus polystachyus*, *V. amygdalina*, *Acacia abyssinica* and *Ficus palmata* is higher than 19%.

The mean NDF content of the selected species of the lowland altitude was 58.6% with a range of 41.0- 80.3% for*Albizzia schimperiana* and *Cordia Africana respectively*. The mean NDF content of the selected IFTS of the mid altitude was 52.7% with a range of 39.7-72.4% for Albizzia *schimperiana* and *Cordia Africana*, respectively. The Mean ADF content of the IFTS collected from the lowland and mid-altitude was43.1 and 28.2%, respectively. It ranges from 26.0% (*Carissa edulis)* to 54.9% (*Gardenia ternifolia)* in the lowland; and from 22.6% (*Vernonia amygdalina)* to 38.2% (*Cordia Africana)* in the mid-land altitude. The average ADL content of the selected IFTS was 21.8% for the lowland and 14.6% for the mid-land.The mean ADL content of the selected IFTS ranges from 9.4% (*Carissa edulis*) to 32.2 %(*Gardenia ternifolia*) in the lowland; while it ranges from 9.1% (*Carissa edulis) to* 18.5% (*Stereospermum kunthianum) in* the mid-altitude. The fiber fraction of forages plays an important physiological and physical role in livestock feeding. It is the major source of energy and stimulates rumen function (Graham and Åman, 1991). It was reported that forage quality depends on the type and composition of fibers in the feed (Van Soest, 1994). Both the in the agro-ecologies and types of browse species significantly (*P*<0.05) influenced the fiber content (NDF) of the browse species in this study. Relatively higher NDF and ADF contents were recorded for the browse species selected from the lowland. Similarly relatively higher NDF and ADF content were recorded for browse trees than from browse shrubs in both low and midland (*P*<0.01). The concentration of ADL was higher for browse shrubs than for trees in the low land, but comparable for trees and shrubs in the mid-land.

The mean 56, 35.4 and 19.7% of NDF, ADF and ADL was recorded from the current study, respectively, the values of which were in agreement with that of Megersa *et al*. (2017) who reported 56.4 and 37.7% of NDF and ADF respectively from selected IFTS

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in Gambella. The same source indicated that the NDF values obtained from the selected browse species of Gambella fall in between 43.5% (A. *leiocarpus) and* 87.0% (G. *tenax). S*henkute *et al*. (2012) reported close values of ADF and ADL to that of the current study. The fiber components of the present study are higher than that of Aster *et al.,* 2012; Muluken *et al*., 2015 and Kassahun, 2016) and lower than 61.7% NDF and 41.7% ADF reported by Diriba *et al., (*2013). However, the mean ADL content recorded from the current study was higher than 9.9% reported by the latter source.

Variations in fiber contents may be associated with species difference and the environment, where the browse species grow. As stated by Norton (1994), forages with relatively lower NDF content (20-35%) are commonly categorized as forages of high digestibility. Since the mean NDF contents of the selected browses of this study were beyond the specified range (moderate), they may not be superior in digestibility, but could fairly be categorized under as moderately digestible. On the other hand, Kellems and Church (1998) concluded that roughages with less than 40% ADF are categorized as of high quality feeds; and those with greater than 40% as poor quality. Even, in case the forages contain lower than 31%, they can be regarded as superior quality (Kazemi *et al*., 2012). Therefore, with reference to ADF content, many of the selected browse species particularly those from the mid altitude fall within the category of <40%. The ADL portion, known to be resistant to digestion, forms complexes with the cellulose and hemi-cellulose fractions and hinders exposure of these fairly digestible cell wall components to microbial enzymes. In similar studies, Raj and Kumar (2006) demonstrated that forages with ADL content of less than 10% are categorized as quality, 10-19% as moderate and more than 20 % as low quality ones. According to the result of this study, about 40% of the selected browse species of the lowland altitude could be categorized as moderate quality, whereas all the selected species of the mid-altitude (exception *Carissa edulis*), could characteristically fall within quality forage.

The average tannin content of the selected browse species was 6.4% with a range of 3.8-8.8% recorded for *Ficus vasta* and V. *amygdalina* in the lowland respectively. The mean tannin content of the mid-land selected browse species was 6.1% with a range of 3.6-8.3% recorded for C. *Africana* and V. *amygdalina,* respectively. The browse species varied significantly ($P<0.001$) in their tannin content in both altitudes. Yet, the tannin content of browse trees was not significantly ($P>0.05$) different from browse shrubs; also with no significant influence of altitude. The overall mean tannin content of the browse species obtained from the current study (6.3%) is slightly higher than the report of Yisehak and Geert (2013) and close to the value reported by Kassahun (2016) who reported 2.8 and 5.8% from Gibe basin and Horo Guduru, respectively. Such differences may result from differences in plant species, temperature, moisture and light as it was stated that high temperatures, water stress, extreme light intensities and poor soil quality increase the tannin content of plants (Rhoades, 1979; Van Soest, 1994). Tannin content also depends on the edible plant parts. For example, tannins are more abundant in new leaves and flowers (which are more likely to be eaten by herbivores (Van Soest, 1994; Álvarez del Pino *et al*., 2001).

As per previous investigations, It would appear that the consumption of plant species with high CT contents (> 50 g kg-1 of DM), significantly reduces voluntary feed intake and depress performance, while medium or low consumption (< 50 g kg-1 DM) seems not to affect feed consumption (Barry and Manley, 1984; Waghorn *et al*., 1994a). A reduction in palatability could be caused through a reaction between the tannins and the salivary mucoproteins, or through a direct reaction with the taste receptors, provoking an astringent sensation (Mc Leod, 1974). Normally, up to 90g kg^{-1} tannin is safe for goats. According to the results of the current study, the tannin content of all the analyzed species is below 9%, indicating that they are suitable for supplementary feeding in the diet of goats. The common and widely available species like *C. africana and F. palmata,* contain less than 5% tannin showing they could contribute towards supplementing sheep and cattle feeds. The tannin content recorded for most browse species in the current study is not too far from the optimum value recommended and may not as such reflect deleterious effect on the performance of ruminant animals. Tannin may also play useful role by altering site of digestion of (increasing bypass) protein enhancing protein availability in the lower gut of ruminants (Mueller, 2005).

The results of this study indicated a considerable variation in nutrient composition of the IFTS studied. There was significant ($P<0.01$) difference between the browse species in mean ash, CP, NDF, ADF, ADL and total tannin contents, in both low and mid-land agro ecologies. The variation in chemical composition may be associated with species, plant part, stage of maturity, climate (temperature, precipitation) and soil conditions (Solomon, 2001; Aster *et al*., 2012). The concentration of the fiber (NDF and ADF) and crude protein in the most edible parts of the indigenous fodder trees and shrubs shows that these plants are potential feed resources for ruminant animals.

Association of Farmers' Perception of Feed Value & Laboratory Analytical Data

The results of the correlation between laboratory analytical data and farmers' perception of nutritive value are presented in Table 7. The comparison mainly considered crude protein, fibers (NDF, ADF and ADL) and tannin contents of each species of IFTS studied to describe fodder quality (Abebe *et al.,* 2008). The correlations between farmers feed value score and laboratory CP values were

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

positive in both agro ecologies. The correlation result was positive and strong (r=0.62; $P<0.05$) in the lowland and (r=39; $P<0.05$) in mid altitude with farmers' feed value score. The overall farmers' feed value score displayed strong and significant (r=0.60; $P<0.05$) correlation with laboratory CP content. The positive relationship of farmers' feed value score with the CP content of IFTS in both agro-ecologies indicates that farmers use their indigenous knowledge in the identification of IFTS with good CP content and supplement animal diets during those dry seasons when the quality and quantity of feeds drop.

Table 7. Correlation between farmers' feed value scores and individual laboratory indicators of nutritive value

Altitude	Farmers feed value score	Laboratory parameters				
		CP	NDF	ADF	ADL	Tannin
Lowland	1	0.62*	0.24	0.06	0.08	-0.08
Mid altitude	1	0.39*	0.10	-0.41	-0.23	0.14
Overall	1	0.60*	0.23	0.03	0.07	-0.04

*Significant at P<0.05

Farmers feed value ranking score assigned to browse species displayed positive correlation (r=0.23; $P>0.05$) with NDF content in both altitudes. Mean ADF content of selected browse species was positively but weakly correlated with farmers' perception of feed value score in the lowland, but negatively correlated in mid-altitude. The correlations recorded in both altitudes were not significant ($P>0.05$). The ADL content of the selected species showed positive correlation ($P>0.05$) with farmers perception of feed value score for the lowland while it was negative in the mid-land ($P>0.05$). Tannin content showed negative correlation with perception of farmers feed value score in the lowland and positive in the midland both of which were non-significant ($P>0.05$). The correlation analysis may show that as farmer's perception of feed value score increases, the fiber content (mainly ADF and ADL) of the selected species somehow showed decreasing trend. This indicates farmers' traditional observation is consistent with the laboratory result and follows the general principles that fiber is often used as a negative index of nutritive value in predicting the total digestible nutrient (TDN) and net energy (Van Soest, 1988).

Feeding Systems of Fodder Trees and Shrubs

The results of the study conducted on feeding system of IFTS are presented in Table 8. The results obtained showed that, the parts utilized, methods and styles of feeding browse plants were similar in both low and mid-lands. In the lowland, the practice of feeding both leaves and pods/fruits is common and this was reported to have been practiced by all the respondents. In the mid-altitude, feeding both leaves and pods/fruits was indicated by 74.3% of the respondents. About 90.9% of the respondents of the study areas were reported to feed both leaves and pods to their animals. About 25.7% of the mid-altitude reported to rely on feeding of the leaves alone. No respondent of both agro-ecologies, reported to have used pods exclusively in feeding. The full utilization of both leaves and pods/fruits at a time seems to be higher for the lowland than the mid-altitude; mainly due to species like *Ficus pamata* and *Cordia Africana* which adequately bear edible fruits/pods are common in the lowland than in the mid-altitude. However, because of availability and better palatability, leaves are the most important browse partsutilized most. This trend is in agreement with the results of the previous studies conducted by Hassen *et al*. (2010) and Jamala *et al*. (2013) who observed that parts of the browse species utilized by livestock were leaves, pods, twigs and flowers out of which leaves were the plant parts mostly utilized by livestock. Fodder is harvested in the natural environments through selective cutting of edible parts, pruning of shrubs and trees which are suitable for livestock and pollarding of tree crowns. Similar observation was reported by Osemeobo (2006).In contrast to the current finding, good experience of drying tree and shrub leaves and storing as hay for dry season feeding was reported in Nigeria (Jamala *et al*., 2013).

Table 8. Plant parts used, feeding mode and forms of indigenous fodder trees and shrubs

Activities	Lowland N (%)	Mid –land N (%)	Overall N (%)
A. parts used			
leaf alone	-	9 (25.7)	9 (9.1)
Pods alone	-	-	-
Both leaves and pods	64 (100.0)	26 (74.3)	90 (90.9)
B. Methods of feeding			
Partial drying(wilting)	2(3.1)	2(5.7)	4(4.0)

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

Supplying fresh	62 (96.8)	33(94.3)	95(95.9)
Complete drying	-	-	-
C. Feeding styles			
Mixed with other feeds	12 (18.7)	7 (20.0)	19 (19.2)
Sole	52 (81.3)	25 (71.4)	77 (77.8)
Both	-	3 (8.6)	3 (3.0)

N = number of respondents

While IFTS are mostly fed fresh without treatment, some of these plants may contain anti-nutritional factors; and Rhamchandra *et al.* (2019) indicated that the effect of anti-nutritional compounds could be reduced by wilting or drying or mixing of the edible parts with other feedsat feeding. Only 3.1% of the lowland and 5.7% of the mid-land respondents reported to have the experience of wilting leaves and pods of IFTS before feeding. About 96.8 and 94.3% of the lowland and mid-land respondents respectively, reported to have used these plant materials as fresh as possible without treatment. There was no experience of drying and conserving of feed resources in both low and mid-land. About 18.7 % (lowland) and 20.0% of the mid-land respondents reported that they mix the fodders with other feeds prior to feeding. In recent study, it was observed that parts of the browse species utilized by livestock (ruminants) were leaves, pods, twigs and flowers. In all browses, leaves were the plant parts mostly utilized by livestock because of abundance and palatability. However, other sources indicated that tannin-rich leaves could safely be fed to livestock combined with other feeds like concentrates because of their high tannin content (Raghavan, 1990; Alagbe et al. 2020).

Generally, the importance of browse species increases with increasing aridity and feed shortage, during dry seasons. This is in line with Jamala *et al*. (2013) and; Megersa *et al*. (2017), who additionally reported that the browses are important for goats during both wet and dry seasons. The use of these feed resources for cattle and sheep is limited almost to the dry season when grasses dry out and drop in quality and quantity. Similar observation was reported by Dicko and Sikena (1992), who indicated that fodder trees and shrubs supply goats and camels with the bulk of their nutrient requirement and complement the diet of cattle and sheep with protein, vitamins and minerals in which most of the crop residue are deficient during the dry season.

4. CONCLUSION

The assessment made on indigenous fodder trees and shrubs (IFTS) has exploited the native knowledge of farmers in setting multiples of preference criteria besides the use of the species for livestock feeding. The selected IFTS have multiples of uses in addition to their feed value. Although trees are able in maintaining greenness throughout the dry season and hence, capable of supporting livestock feeding, shrubs which grow following riverbanks also appear green during the dry season too and therefore, they were equally important as fodder trees. Because of their long root to enable them draw water deep from the ground, and since some broad leaved trees also have waxy leaves to conserve moisture to stay green; trees were found better in score values of biomass and greenness than shrubs.

The correlation between the farmers' native knowledge and laboratory analysis appears to be promising to combine it in a comprehensive approach of assessing and selecting, and adopting the fodder species of particularly multiple advantages that well satisfy the interests of the people in the area. The experience of drying and storing the edible parts of the browses for times of feed shortage was poor. Therefore, it could be suggested that the practice of fodder conservation needs to be promoted, and this would enable livestock keepers to preserve the adequately available browses of the wet season for the dearth period of the year which might also enable researchers to evaluate these feed resources on animal performance.

Funding
This study has not received any external funding.

Conflicts of interests
The authors declare that there are no conflicts of interests.

Data and materials availability
All data associated with this study are present in the paper.

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ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

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ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS